ART. VIII.—*A New Point of Resemblance in the Respiration of Plants and Animals.*

BY JAMES JAMIESON, M.D.

[Read 13th June, 1878.]

RESPIRATION in plants consists just as it does in animals, in the inhalation of oxygen and the exhalation of an approximately equivalent quantity of carbonic acid. This process, though masked under ordinary circumstances by the more active deoxidizing action of the green parts of the plant, seems, according to recent investigations, to be constantly going on, and to be as necessary to the life and health of the plant as of the animal. The deoxidizing action of the green organs, carried on by means of the chlorophyll contained in them, is tolerably well known, and consists in the splitting up of carbonic acid into oxygen and carbonic oxide. The oxygen is wholly, or in great part, set free in the air, while the carbonic oxide seems to enter into some kind of combination with the chlorophyll, as a preliminary to the formation of more complex compounds, and especially of the various hydro-carbons. A series of investigations on this point are contained in a paper by Adolf Baeyer, in the *Chemisches Centralblatt*, 1871, pp. 27—38, and also translated in a slightly condensed form in the *Journal of the Chemical Society*, 1871, pp. 331—341. My object is not, however, to enter into any details on this process, which is one of assimilation, but rather to consider the mechanism of respiration in the proper sense of the word, which is essentially associated with processes of regressive metamorphosis. Some observations which I have made seem to throw light on the chemistry of the respiratory function in plants, and I desire therefore to report the result of them, incomplete and fragmentary as they are.

For the proper understanding of the particular point on which I wish to lay stress, and which, after consulting the best accessible authorities, I am led to believe is new, or at least very little known, it will be necessary to mention certain facts connected with the better-known chemistry of the function of respiration in the higher animals. The red colour of blood is due to the presence in it of large numbers of discs or corpuscles, infiltrated with a red colouring matter of very complex constitution called hæmoglobin. These red corpuscles take up oxygen while the blood is passing through the capillaries of the lung, the oxygen entering into loose combination with the hæmoglobin. As the blood flows in the systemic circulation through all parts of the body, the oxygen is gradually given off, and enters into definite combinations with the tissues undergoing disintegration; one of the main ultimate products of the oxidation process being carbonic acid, which is taken up by the blood and carried to the lungs, there to be exchanged for a fresh supply of oxygen. The following passage from *Hermann's Physiology* (English translation, p. 47) gives shortly what is generally admitted as to the properties of the oxygen contained in the blood, though there is not perfect unanimity on all points, as I will afterwards show:—"As blood when saturated with oxygen takes up exactly as much of that gas as corresponds to the amount which its hæmoglobin can combine with, it follows that all the loosely combined oxygen of the blood is linked to hæmoglobin. The oxygen of the blood is given up so readily to oxidizable substances that it has been thought to be present in the form of active oxygen, or ozone O_3. The following properties of blood appear to favour this view:—(1.) Both the blood corpuscles and hæmoglobin are so-called 'ozone-transferrers'—that is, they possess the power of immediately transferring ozone from substances in which it is present (as turpentine which has been kept for a long time) to readily oxidizable substances (ozone reagents, such as tincture of guaiacum, which becomes blue by oxidation—Schœnbein, His.); for this reaction the presence or absence of oxygen in the blood is of no importance (for instance, it may be saturated with CO). (2.) Blood and hæmoglobin can themselves ozonize oxygen, so that in presence of air they can cause guaiacum tincture to become blue (A. Schmidt); if the blood itself contains oxygen the presence of air is not necessary; it is necessary if the blood has been saturated with CO (Kühne and Scholz). On the activity of its oxygen depends the decomposition of sulphuretted hydrogen by blood. It is therefore very probable that the oxygen naturally contained in blood is present in the form of ozone, or in some similar condition."

With regard to the first of the properties, viz., the power possessed by hæmoglobin of acting as an "ozone-transferrer," there is no room for difference of opinion, that quality indeed being made the basis of a valuable test for blood, with which the name of Dr. Day, of Geelong, is associated. Tincture of guaiacum and peroxide of hydrogen may be brought together without any change of colour appearing; but as soon as a minute trace of blood or hæmoglobin is added a deep blue is struck. The presence of ozone in the blood, as first asserted by Professor Alexander Schmidt in 1862, and confirmed by W. Kühne (*Lehrbuch der Physiologischen Chemie,* 1868, p. 214) and others, has been doubted by some physiologists, and indeed quite lately by Dr. Michael Foster in his *Textbook of Physiology,* first edition, 1877, p. 240. As there is not yet by any means unanimity of opinion as to the nature of ozone and its characteristic reactions, the dispute may be mainly about names, there being really agreement that the oxygen in the blood is more active, *i.e.,* combines more readily with reducing substances, than the ordinary form existing in the atmosphere. The transformations undergone by oxygen in the vegetable economy do not seem to have been traced in the same way. For the purpose of discovering the present state of knowledge on the subject I have gone through the most likely sections in Sachs' *Textbook of Botany,* in Watts' *Dictionary of Chemistry,* including the supplements, and in the *Dictionnaire de Chemie,* of Wurtz, as well as through the articles most likely to touch on the subject in the *Journal of the Chemical Society,* and the *Chemisches Centralblatt* for the last few years, and have been able to find nothing but the vaguest statements. My own observations were first made some years ago in the course of a series of experiments mainly designed to test the reliability of the guaiacum test for blood, the results being embodied in a paper in the *Australian Medical Journal* for October, 1869. At that time I did not see the full bearing of these observations on the subject now under discussion; but having occasion again to take the matter up recently I have been able to reach more definite conclusions. The recent experiments have been made chiefly with fruits of different sorts, especially apples and pears, though what is true of them holds good of most other fresh vegetable structures and expressed juices. If a drop of tincture of guaiacum be allowed to fall on a freshly cut surface of an apple or pear, which has not been too long pulled and is not decayed, it will generally be found that a blue colour is quickly struck. Again, if a few crumbs of biscuit or other cooked starch are sprinkled on a similar surface, and a little of a strong solution of iodide of potassium added, the starchy particles will become gradually brown and then black from the formation of iodide of starch. Here, then, we have the recognised reactions characteristic of the presence of ozone. The rapidity and intensity of these reactions will be found to vary with different articles or different specimens of the same article; and they may fail altogether, as in very watery fruits, such as some grapes, though even with these the guaiac reaction may be perceptible in a green berry from the same bunch. I have not observed this reaction with the soft pulpy fruits which quickly decay, such as the strawberry or peach, perhaps because the specimens were not fresh enough, while with the apple and pear both reactions may be obtained though the fruits have been pulled for a considerable time.

With reference to the agent providing these reactions it may certainly be said:—(1.) That it is not merely ordinary oxygen absorbed and dissolved in the vegetable juice; and this, both on account of these reactions and from the fact that Cahours (*Comptes Rendus*, 1864, LVIII., pp. 495 and 653) could obtain carbonic acid gas and nitrogen, but never oxygen, from expressed fruit juices. (2.) It is not newly-formed oxygen, separated by the chlorophyll, which may possibly in part be diffused into the structures below the surface as well as liberated into the atmosphere, since Pellucci has shown (*Chemisches Centralblatt,* 1872, p. 356) that the oxygen developed under water in sunlight by various plants does not act on starch and iodide of potassium like ozone, agreeing therein with the results obtained by Mulder and others, *v.* Hoppe-Seyler's *Physiologische Chemie,* 1877, p. 47. These reactions are also given by sections of pulled fruits, which, though capable of carrying on a process of respiration for a time, no longer liberate oxygen; and also by underground organs like the potato, turnip, &c., which never perform that function. (3.) It is not probable, in spite of these reactions, that the substance is actually dissolved ozone, since it is scarcely conceivable that it could continue to co-exist for any length of time with the complex mixture of solid and dissolved organic matters contained in fruits. We are therefore in a manner shut up to the conclusion—(4.) That the oxygen is in a form of loose combination, as it is in the blood, and therefore capable of being slowly given off in a very active form to combine definitely with oxidizable substances. Cahours *(op. cit.)* and others often since have found that fruits, during their period of growth, appropriate carbon and give off oxygen, like other green parts of the plant; but that when ripening they cease to do so, and begin to inhale oxygen and give off carbonic acid; the chemical changes taking place during the process of maturation being essentially oxidation phenomena. It is also well established that many fruits, such as the apple, the pear, and the orange, continue the maturation process after separation from the parent stem, acting in a manner like independent organisms. If placed in a close vessel containing air, a portion of the oxygen gradually disappears, and is replaced by carbonic acid. A difficulty was felt by Cahours in explaining the continued exhalation of CO_2 from fruits enclosed in an atmosphere of nitrogen or hydrogen, which he could ascribe only to some fermentation. Fremy, in a note to the communication of Cahours, tries to explain it as being due to the slow process of combustion going on in the interior of the fruit, which is no doubt true; but is at the same time rather an insufficient explanation, without some account such as is here given of the state in which the oxygen exists while that slow combustion is going on, the full explantion being that the oxygen is stored up in loose combination, to be given off as required for the formation of oxidation products and among them CO_2.

With reference to the substance with which the oxygen is temporarily combined I cannot speak very definitely; it is certain, however, that in fresh fruits and other vegetable substances there is an element which is possessed of the same ozone-transferring property as hæmoglobin. If a fresh section does not supply spontaneously the blue colour on the application of tincture of guaiacum, it can be brought out by the addition of a drop of solution of peroxide of hydrogen; and if it had appeared spontaneously, the peroxide has the effect of rendering the blue more intense. I have found that in fruits, when long-kept, the ozone reaction is gradually enfeebled, the power of inhaling oxygen being lost and the amount stored up gradually consumed. On the other hand, the ozone-transferrer may still be detected when the fruit has become over-ripe and has entered on the stage of incipient decay, disappearing entirely, however, in parts which have become actually rotten. When fruits, &c., are cooked either with moist or dry heat, both this substance and the active oxygen are destroyed, no blue colour being produced by guaiacum alone or on the addition of peroxide of hydrogen. It is known that other substances contained in the animal economy, and belonging to the protein group, such as fibrin, myosin, globulin, act like hæmoglobin in the way of carriers of ozone. I conclude, therefore, from analogy, as well as from its properties above described, that in fresh vegetable substances there is contained an ingredient, probably albuminous, which acts as an ozone-transferrer, and may be presumed to be the agent with which oxygen enters into loose combination. It certainly is not chlorophyll, which has been compared with hæmoglobin (by Baeyer in his paper referred to above) on account of the property which they possess in common of combining with CO. The difference in function, however, is well marked, chlorophyll causing the elimination of oxygen, while hæmoglobin enters into combination with it. In addition, the substance whose nature I am considering exists abundantly in the interior portions of fruits and in many other structures, such as the potato, turnip, &c., which never contain chlorophyll. I think it probable that considerable difficulty will be found in isolating this substance, both on account of its destructibility and because it is almost uniformly diffused through fresh vegetable structures. It is probably intimately associated with the vascular-tissue, since I have found that the ozonic reaction, as well as the ozone-transferring function, in fruits are most marked and persistent near the core, where the vessels from the stalk are more abundant than in the outer, more purely cellular, parts. A perhaps more doubtful opinion is that this substance is attached to the small cells or granules, called by Sachs "aleurone grains," which, according to him, are mainly proteinaceous. They resemble somewhat in size the red blood corpuscles, and I have sometimes thought that minute sections of fruits, which had been rendered blue by guaiacum, when examined under the microscope showed the most intense colouration at the spots where these aleurone grains occurred in groups.

Whether what I have ventured to advance by way of opinion prove to be correct or not, the following points have, I think, been established:—(1) That the oxygen inhaled by plants as well as by animals enters first into some form of loose combination whereby it is ozonized or rendered active; and (2) that plants contain a substance, other than chlorophyll, having some important points of analogy with the hæmoglobin of animals, acting like it as an ozone-transferrer. It cannot, however, yet be regarded as more than fair presumption that this substance is that with which oxygen becomes loosely combined.

Art. IX.—*Note of the Great Meteor of June 8th,* 1878.

By R. L. J. Ellery, F.R.S.

[Read 11th July, 1878.]

There is one point in connection with the apparition of the great daylight meteor of June 8, 1878, which is remarkable and interesting—that is the apparent exactness with which different observers, hundreds of miles apart, erroneously localise certain phases of the phenomenon, and the imaginary *nearness* to the observers at which these phases occurred, leading one to the conclusion that usual human experience in judging of distance, &c., is altogether at a loss in the case of such phenomena as this. The meteor appeared about 3 p.m. on June 8, and was seen at Sydney, off the N.S.W. coast at sea, at Yass, Braidwood, Cooma, Omeo, over many parts of Gippsland, at Geelong, Ballarat, Seymour, &c., &c., and by sifting all the reports, and allowing for difference of local time, *all about the same time.* There can be no doubt it reached its minimum distance from the earth somewhere in the zenith of Kosciusko, and passed nearly over the zeniths of Cooma and Omeo. From Seymour it was seen in the east, about 30° high; from this its height may be roughly estimated as over 100 miles, while by two different observers at different places a bursting-up of the meteor was witnessed, followed at an estimated interval of from 10 to 15 minutes by loud explosions—most probably one explosion and its aerial echoes. This would give us an estimate of its distance from these observers of nearly 200 miles.

At Cooma, Yass, and about that district, it was firmly believed to have come to the earth in the neighbourhood, and to have fell by the side of Jellimatong; indeed, it was reported that fragments were picked up in that district. The explosion seemed to be quite close to the observers, and was called by some an earthquake.